Report of Activities

1988 - 1989

90-06616/

Report of the Director and the Board of Governors

1988-1989

The year of 1988-1989 has been a very productive and successful year for C-CORE. There has been significant growth in all research areas and many of the major goals set in the five year research plan have been achieved. Productivity has been very high. The number of papers published in refereed journals and conference proceedings has increased; project funding has been secured to support the growth in the research activities; and there has been an increase in the number of staff who have joined C-CORE to undertake these activities. Significant accomplishments have also been made in the field of technology transfer.

This year has been very active; several major field and laboratory programs have been completed. A major study in ice structure interaction has been undertaken by the Ice Engineering Group working on the Nekton 8000, a concrete semi-submersible designed by the Nekton Joint Venture (Bouygues Offshore Canada Limited, Newfoundland Design Associates Limited and Pennecon Limited). The Labrador Ice Margin Experiment (LIMEX) '89 was carried out on the Grand Banks during the winter months. Over 20 organizations were involved in the program which included activities in remote sensing and in ice. LIMEX was first conceived at C-CORE in 1984 and since then, many Canadian and international groups have become involved in the program. C-CORE's major interest in the project is the study of the motion of the ice under wave action and the engineering properties of the ice. The Centre's participation in LIMEX was made possible by two Natural Sciences and Engineering Research Council (NSERC) co-operative R & D grants with industrial support in 1987 by Mobil Oil Canada Properties and in 1989 by MacLaren Plansearch.

The program to design and build the Conventional Optimization Acoustic Sub-seabed Interrogator (CO-ASI), a geophysical tool which will undertake cost effective seabed site surveys, has caught the interest of industry. Major funding has been made available by Petro-Canada, Esso Resources Canada, Mobil Oil Canada Properties, Gulf Canada Resources and NORDCO Limited. These funds have been matched under an NSERC co-operative R & D grant. Following a successful field program, the CO-ASI is now being upgraded for operation in the Beaufort Sea in 1990. Norwegian groups are extremely interested in the technology and will be involved in the development of a deep CO-ASI for application in the North Sea.

Investigations of relict ice scours in Manitoba continued and produced further data to assist in understanding the behaviour of the seabed below a scouring iceberg. A submersible program to gather further information from recent scours is proposed for the Labrador Sea in the summer of 1989. A contract from Fleet Technology Ltd. on behalf of the Panel of Energy Research and Development extended the laboratory study on ice scour.

New programs within the Seabed Geotechnics Group include the application of Geographical Information Systems (GIS) to seabed and environmental problems and the development of a marine electromagnetic system that would enable the detection and identification of heavy minerals in nearshore placer deposits. Initial steps have been taken to secure a major Centrifuge Facility for St. John's with industrial and governmental participation. The facility will be dedicated to research related to cold regions engineering problems and will be available to all interested researchers in North America. It has been strongly endorsed by research work throughout Canada and the United States.

Other new research areas in C-CORE this year include the development of an integrated model for iceberg and sea ice forecasting and marine icing. Both programs have been identified by industry as important technical issues which should be addressed. Funding through the Offshore Development Fund has been secured for the model work and the Centre is already responding to requests from industry to assist them with their information needs.

The research programs in Remote Sensing are perhaps the most mature of the programs within C-CORE. This is demonstrated by the successful technology transfer process now underway. Northern Radar Systems Limited (NRSL), established to commercialize the Ground Wave radar technology for shore based systems, began its operations in November 1988 with the appointment of a managing director. Funding has been secured from Atlantic Canada Opportunities Agency (ACOA) and from a Newfoundland venture capital group to build a full scale prototype system at Cape Race, Newfoundland. C-CORE continues to be involved in the technical aspects of the project to ensure that the specifications for both commercial and military work are met. Completion of the prototype is scheduled for June of 1990.

The development of Ground Wave radar technology for rig based systems is proceeding on schedule. A field experiment on the coast of Newfoundland has provided important data on the detection of small ice masses. The upgrading of the CODAR (Coastal Ocean Dynamics Applications Radar), working with SeaConsult Marine Research Ltd, has been successfully completed. The radar can now be operated remotely and produce surface current maps in real time.

C-CORE has attracted a number of new staff. The current staff level is close to exceeding the maximum which can be accommodated within the existing space of the Bartlett Building. Various alternatives are now being explored to resolve this situation. In spite of these problems, the staff of the Centre work well within a team environment and this is reflected in the increased productivity of publications, both in published papers and in contract reports.

The growth of C-CORE has been carefully controlled within available budgets and within the five year financial plan. Each project has a schedule and a budget which is reviewed regularly. Each quarter, the group leaders meet predetermined financial targets. With an increase of nearly $667,367 in contract funds for projects, the Centre finished the year at an operating level of $2,948,497, showing a growth of $749,771 from the previous year. The matching fund target for the Offshore Development Fund monies was achieved within the first quarter of the fiscal year. Support-in-kind from Associates is integral to the overall success of C-CORE. This year, the Centre has received support-in-kind from Associates and Memorial University totalling $956,369.

A research organization such as C-CORE must always be sensitive to market demand and economic forces and continually adjust to these to remain viable. The major initiative within the Newfoundland R & D community, OCEANS 2000, demonstrates the increase in ocean related capability in the province. Long term planning is recognised as an essential component of research and development. Many organizations are now developing five and ten year plans. C-CORE's first five year plan for 1985 -1990 underwent a major revision in 1987 and again in 1989. These revisions undertaken every two and one half years through a five year research plan ensure that the research at C-CORE addresses the most urgent priorities as identified by industry and government. Involvement of industry and government in the research planning process is now standard procedure at C-CORE. Their input to the identification of important technical issues to be addressed is central to the success in securing funding to undertake the work. As a result of this input, a new research plan will be considered by the members of the Board at their November 1989 meeting in St. John's.

Much of what C-CORE has accomplished within this year, as in many others, could not have been done without the direction and guidance given by the Board of Governors and the Associates. Their experience in key positions with industry and government, their knowledge of the value of Research and Development to the economical and safe development of offshore resources and their assistance with technology transfer has provided invaluable support to the Centre. Their contribution to the success of C-CORE is gratefully acknowledged.

The fiscal year 1988/89 has been one of growth for the Centre. Practically all major research projects are now undertaken with partners from industry, and government as well as other universities. This not only results in more cost effective research and development but it also assists in the orderly transfer of technology to the market place. This upcoming year will see C-CORE well positioned to undertake new challenges and respond positively to new opportunities.

J.I. Clark
Director of C-CORE

G.C. Eaton
Chairman of the
Board of Governors

Board of Governors of C-CORE

1988 - 1989

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Manager, Frontier Production Engineering
Canterra Energy Ltd.

Ice Engineering and Special Projects

Ice Dynamics

The Sea Ice Environment

The LIMEX (Labrador Ice Margin Experiment) Program is directed to advance the knowledge of physical environment associated with the ice covered ocean. The project emphasizes the use of remotely sensed data particulary synthetic aperture radar (SAR) imagery to enhance research carried out at the surface of the ocean. The ice covered region is immense and even major surface based programs, like LIMEX '89, can only expect to sample in a limited area. The remote sensing program successfully expanded the observation area by major proportions. LIMEX '89 was the second major field program; LIMEX '87 was the previous one. This year's program showed that when dealing with the ocean environment aircraft programs are severely limited in range and by weather. Future programs will include satellite platforms such as ERS-1 and RADARSAT.

The SAR imagery from 1987 indicated wave penetration within the ice cover was a major component of the ocean/ice interaction process. C-CORE's expertise in ice motion measurement was identified as the logical way to obtain the surface measurements required to investigate wave/ice dynamics. Data using the motion sensor packages were collected during the 1989 program. The results of this work are expected to further the knowledge of waves at the ice margin, ice conditions within the ice margin, and remote sensing of waves in ice and to contribute to ocean wave remote sensing.

MacLaren Plansearch and C-CORE were awarded an Unsolicited Proposal contract to carry out a research program on wave/ice interaction. The contract was jointly supported by Coastal Oceanography of Bedford Institute of Oceanography and the ocean remote sensing group of the Canadian Centre for Remote Sensing and the RADARSAT Project Office. The Centre used this collaboration with its private sector partner to lever additional funding through an NSERC Co-operative R&D Grant. Dr. Branko Ladanyi, of Ecole Polytechnique is a co-investigator on this NSERC award. The research will address the role of ice strength in wave ice dynamics and the impact of air/ice/ocean processes on resource development scenarios. The physical processes to be investigated influence structure design, marine operations and transportation in offshore development and in fishing operations.

Research team from C-CORE and MacLaren Plansearch Ltd. setting up instruments on the sea ice during LIMEX '89. The *Terra Nordica* can be seen in the background.

Antarctic Project

As a continuation of the co-operation with France, we proposed to undertake a joint project with the Terres Australes et Antarctiques Françaises (TAAF). The project aimed at measuring collisions of icebergs with the seabed, a cliff or each other in order to estimate the strength of icebergs at a large scale. Instruments and techniques which were to be used included: 1) a six degree of freedom motion package; 2) an underwater sonar profiler; 3) aerial stereo photography; 4) underwater photography; and 5) iceberg towing. The quantities to be measured were accelerations and shapes from which mass, inertia and impact force could be deduced.

Due to severe and unexpected mechanical problems with the French polar vessel *L'Astrolabe*, the project had to be postponed one week before deployment. It is now re-scheduled for January-February 1990.

Salmon Aquaculture

Working through Seabright Corporation, C-CORE has been retained by the Bay d'Espoir Salmon Growers Co-operative to assist in the modelling of ice growth at the fish farm in Roti Bay on the south coast of Newfoundland. Last year, high fish mortality was experienced and was thought to be caused by the ice cover. The project, completed by the summer, produced analytical, predictive models and made the first step towards evaluating mitigating techniques to prevent fish mortality over the winter.

Ice Structure Interaction

Nekton 8000: (Nekton Joint Venture)

A major study on the Nekton 8000 involved all the members of the group since the fall. Work is completed on the study of the behaviour of a proposed concrete semi-submersible to be used for oil production in ice infested waters. The program was carried out in four phases:

1. Environmental Survey: Survey of sea ice, iceberg, wave, wind conditions on the Grand Banks. This phase has been completed with a final report to Bouygues Offshore Canada.
2. Wave-Bergy Bit Impact Tests: A 1/75 scale model was fabricated, instrumented with pressure sensitive piezoelectric film and moored in a wave tank. Cubes of wax were introduced that simulated bergy bits of 1,000 t and 5,000 t. The impact velocities were measured for regular waves and one irregular wave spectrum by an optical device coupled with computer graphics (SELSPOT). Tests were completed successfully, and produced a statistical distribution of impact velocities.
3. Sea Ice: A 1/45 scale model was also fabricated by C-CORE and was tested in sea ice (solid sheet and pack ice). The tests were carried out in the ice tank at the Institute for Marine Dynamics, with the model in a fixed and a moored configuration in head, quarter and beam seas.
4. Numerical Model and Risk Analysis: Numerical models were developed to compute iceberg impact load by simulation. The probability of occurrence of various load levels and downtimes were estimated.

Ice Forces on the Molikpaq

The work on the NSERC Co-operative R&D program has been concluded. In this program, motion sensors and strain arrays were built to instrument ice floes that could collide with the Molikpaq. Gulf Canada Resources Ltd. provided financial support. The instrumentation part of the program was completed successfully; two motion sensor packages were built. Unfortunately, unfavourable ice conditions in the Beaufort Sea (no multi-year floes) were experienced prior to the Molikpaq being taken off its site, so the field component of the program could not be completed. Other sites, such as Katie's floeberg off Alaska, were explored as alternative field locations. A number of industry groups were invited to participate, but extra funding was not found to support their participation. Although the field component of this program was not executed, C-CORE acquired two motion sensor packages which will now be used in the LIMEX program.

Model of the Nekton 8000 FPV

Site of the C-CORE/IMD field program to test mechanical properties of first year sea ice - Resolute, NWT.

Ice Information

Sea Ice and Iceberg Drift Forecasting

There is strong interest in the sea ice forecasting project. Site specific forecasting to support tactical operations was given a high priority at the PERD (Panel of Energy Research & Development) workshops at the Bedford Institute of Oceanography in November and in Ottawa in December 1988.

Under the direction of Mona El-Tahan, C-CORE and CORETEC have been awarded an ODF grant to enhance an integrated sea ice and iceberg forecast system.

The main objective of the project is to develop and implement an integrated ice/iceberg forecasting system (IIFS) designed especially for safe offshore operations, particularly during the period of increased activity caused by oil production on the Grand Banks. The integrated system will include three models for regional and site specific forecasts of the drift of (i) iceberg trajectory, (ii) iceberg ensembles, and (iii) sea ice edge. The system will also include an iceberg deterioration model and the necessary data bases on currents, iceberg parameters, wave forces, historical drift patterns and sightings of icebergs and sea ice edge extents, and will incorporate and use the Computerized Data Base Management System Package. Further work on iceberg stability and the effect of towing on iceberg stability will also be investigated.

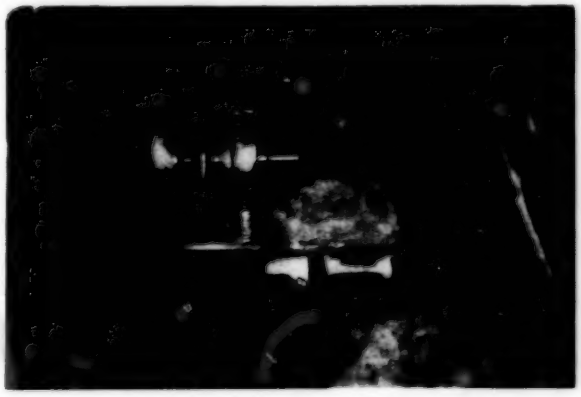
The proposed system will provide detailed site specific and time-specific forecasts tailored to client needs. It will complement the Berg Analysis and Prediction System (BAPS), and Ice Data Integration and Analysis System (IDIAS), which are currently under development by the Atmospheric Environment Service. The IDIAS and BAPS systems are designed principally to provide regional analyses and predictions of ice and iceberg distribution for the entire east coast for a wide range of users.

Mechanical Properties

Marine Spray Icing

A research proposal to develop icing instrumentation has been formulated. It concentrates on the ability to detect the onset and growth rate for sea spray icing. Some samples of spray or splash ice were collected through the winter to provide salinity values for coastal ice. Splash ice material can be compared to the icing build-up which would accumulate on a sensor probe.

We will continue to explore the research needs and priorities for icing work. Discussions with one service vessel operator stressed the importance of icing countermeasures. He emphasized the importance of developing effective icing countermeasures rather than information to support evasive action. This will allow them to operate through periods of marine icing.



Indentor - ice indentation tests, Resolute, NWT.

Seabed Geotechnics

The Seabed Geotechnics Group is actively pursuing its research objectives as portrayed in the five year research plan. Marine geoscientific research has expanded to include aspects of environmental monitoring/assessment, artificial intelligence, induced polarization technology and geographical information processing. As new tools become available, they are being incorporated into research projects.

Marine Geophysics

Geophysical/Geotechnical Sediment Property Correlation

Relationships have been established between acoustic properties (velocity and attenuation) and geotechnical properties (density, porosity, shear modulus, and damping) of selected sediments in support of the Acoustic Sub-seabed Interrogator (ASI) and its associated developments.

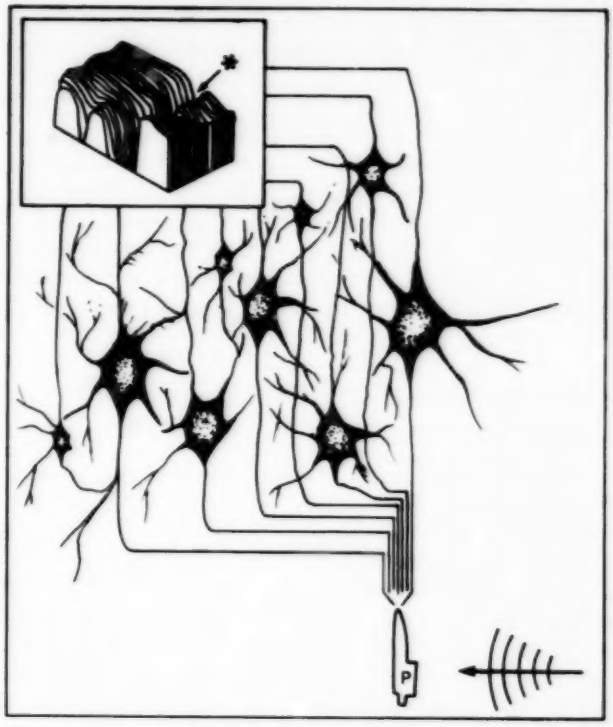
The final report to PERD on the geophysical/geotechnical sediment property correlation study incorporating the reviewer's comments was written. An NSERC Operating Grant has been awarded to Dr. Guigné for continuation of this research.

Robotics and Intelligent Systems

Neural network theory is being applied to acoustic intensity data. Neural models have been selected and interfacing of the intensity analyzers with the neural computer is under way. The neural models will utilize spectral data from the analyzers in an attempt to recognize and match patterns of energy flow within structures. Future plans include application of the neural network models to analysis of vibrations in ship structures, ultrasonic testing of defects and probabilistic modelling of statistical information derived from Geographical Information System (GIS) ice scour models under development in the group.

Marine Resistivity and Induced Polarization: New Program

Discussions with potential clients in both government and the mining industry have culminated in a proposal to develop a marine induced polarization (MIP) system for marine mineral exploration and identification of offshore hazards (e.g. permafrost). The proposal has received support from several government agencies and industry groups. Field testing will take place in Conception Bay and at ground-truthed sites in New Haven, Connecticut and offshore South Carolina. After proving the technique, field studies will be undertaken in Hecate Strait, B.C. and in the Beaufort Sea.



Detection of Fatigue Cracks in Underwater Structures: One potential application of neuron-like processing.

Innovations in Acoustic Technology Offshore

A CO-ASI (Conventional Optimization Acoustic Subseabed Interrogator) based on the ASI concept, is being designed and fabricated. It will include advanced design, multi-tip acoustic transmitters designed and fabricated at C-CORE. The CO-ASI is being engineered to perform layer-by-layer interrogation of a complex sub-seabed to a depth of 30m. High-resolution acoustic information will be acquired and related to physical and geotechnical soil properties.

An extensive field simulation of the CO-ASI took place in October, 1988. The data is being processed using geophysical data processing software and hardware from Advance Geophysical of Denver, Colorado. Field tests are scheduled for summer/fall, 1989 to verify the effectiveness of a working shallow water CO-ASI.

Drs. J. Guigné and J. Clark have been awarded a Natural Science and Engineering Research Council (NSERC) University-Industry grant entitled "Innovations in Seismic Sub-Seabed Profiling". The grant, which began in January 1989, provides a year's support for field testing of a shallow water CO-ASI prototype. A second year contribution is scheduled for 1990, provided that the research continues to meet its proposed objectives. The industrial partners supporting the program are Mobil Oil Canada Properties, Esso Resources Canada Ltd., Gulf Canada Resources Ltd., Petro-Canada Resources and NORDCO Ltd.

Sound Intensity Techniques to Study Fatigue in Offshore Structures

The Dynamic Acoustic Intensity Scanning (DAIS) project involves the development of technologies and methodologies for the remote determination of fatigue cracking in offshore structures. It is part of a long-term study in cooperation with the Canada Centre for Mineral and Energy Technology (CANMET). The final report to CANMET on the 1987-1988 work has been accepted; discussions on further funding are continuing. An NSERC equipment grant has been awarded to several researchers at Memorial including Dr. Guigné for fatigue related studies. Research in acoustic emission on ice has been initiated on land with good results. In addition, ultrasound scanning of ice has been attempted in the Arctic.

C-CORE has recently acquired a second sound intensity analyzer. With a third analyzer loaned to us by NORDCO Ltd., sound intensity vectors in three dimensions can be measured simultaneously. This measurement represents a unique contribution to acoustic intensity research.

The scour left after the deep incision - soil tank Faculty of Engineering and Applied Science, MUN

Marine Geotechnics

Ice/Seabed Interaction

Ice scour research, supported by an NSERC strategic grant, continues to provide information on the mechanics of the scour process and its effects on the soils both above and below maximum scour depth. The second field trip to the relict scours in Manitoba took place in mid-September, 1988. The results indicate that, contrary to earlier ideas, soils are disturbed to some depth below the ice keel. Further work is directed to establishing the generality and significance of these indications. The ultimate goal of the research is to provide quantitative models of ice scour processes for engineering design.

Ballistic Penetrometer Development: New Program

Development is continuing on an instrumented ballistic penetrometer for geotechnical soil characterization. At present the device is capable of measuring acceleration, and nose and sleeve resistance. The next sensors to be engineered are the pore pressure transducer and inclinometer. Correlations of penetration data with ground-truth data will enhance ongoing theoretical modelling efforts.

Centrifuge Modelling: New Program

A proposal to undertake a marketing study for the establishment of a centrifuge modelling facility in St. John's has been submitted to the provincial government. The centrifuge would be used to model events such as ice properties, iceberg grounding and earthquake effects. Wide support has already been received from industry and government to establish the centrifuge.

Marine Geology

This program is providing a fundamental understanding and first order assessment of the marine mineral potential of the Canadian continental shelf and developing innovative technological methods of exploring for marine minerals.

Offshore Mineral Resource Evaluation

The Mineral Development contract final report has been submitted. Additional funds are expected, but are contingent upon the renewal of the federal-provincial agreements.

The Penetrometer/Shear Vane. This configuration was used after the first stage in the evolution of its design.

Strait of Belle Isle

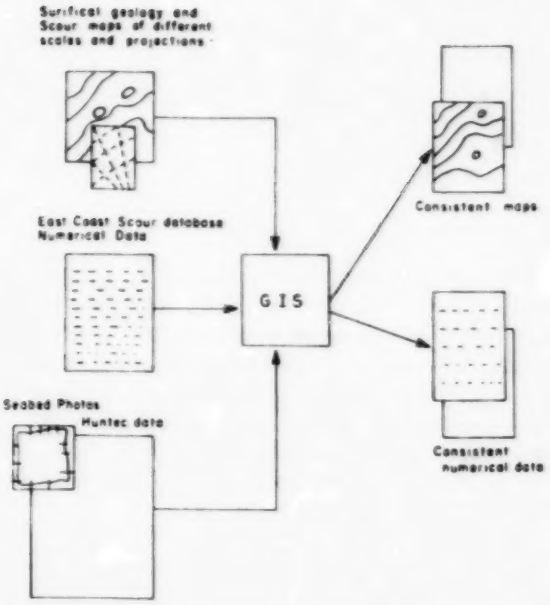
The compilation and evaluation of the Newfoundland and Labrador Hydro database on the Strait of Belle Isle to assess geological and engineering implications has been a significant program during the last two years. This database encompasses 20 years of investigations in a geologically complex area. Compilation and integration of this database with existing geological work will provide considerable insight into the structural and Quaternary history of the Strait. Geotechnical data on material quality and strength as well as seabed morphology will permit impact assessment of the geology on future developments.

Geographical Information Systems (GIS): New Program

The new program is developing a GIS-based system which will examine multi-variate spatial relationships between ocean-related variables and seabed features and properties. The spatial model for iceberg scouring on the Grand Banks will synthesize iceberg information, sea ice coverage data, wave and current regimes, iceberg scour data, surficial geology, bathymetry and other complementary environmental data.

Environmental Assessment and Monitoring: New Program

A final contract report on acoustic monitoring systems for sediment transport in the Great Lakes has been submitted to the National Water Research Institute. Three specialized parametric arrays have been built, two for environmental work and one system for materials testing at the Marine Institute.



Data consistency created by GIS permits a comprehensive analysis of data.

Remote Sensing

Basic Research

Electromagnetic (EM) Propagation and Scatter

The development of new techniques for the solution of electromagnetic problems will lead to a greater understanding of the fundamental propagation and scattering of EM waves and will enhance the use of EM for remote sensing. These techniques are now being applied successfully to solve a variety of problems including propagation and scatter for the ocean surface, and the prediction of iceberg radar cross section. They are also used to estimate scattering from metallic targets, such as vessels on the ocean surface. New techniques are being developed to predict the radar cross-section from these metallic targets and will be extended to targets above the ocean surface such as aircraft. Methods developed in these studies may be applied to projects which use other modes of radar propagation.

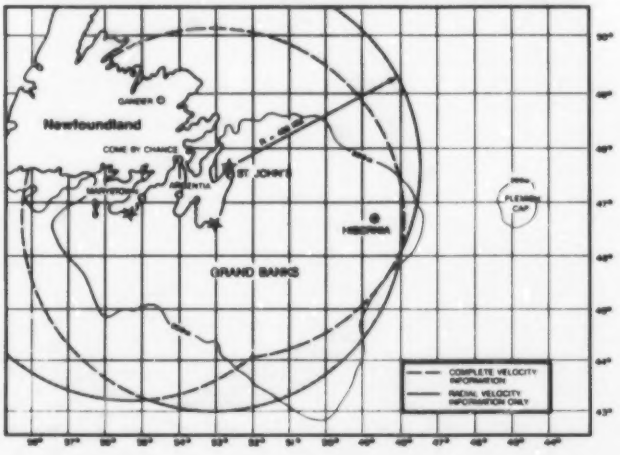
Signal Processing/Data Analysis

A significant research effort in signal processing and data analysis is required to develop new algorithms to extract and enhance information on ice and ocean hazards in the EM signals. The research program is focusing on ocean clutter reduction and enhancement, spectral estimation techniques and signal detection. The methods developed in this program for extracting information from the EM signals will have application in other engineering research areas which involve signal processing.

Radar Cross-section Modelling: Contract

C-CORE was awarded a Department of National Defence (DND) contract to continue the development of a radar cross-section for targets on or near the surface of the ocean. The work will be applicable in the detection of icebergs, ships and aircraft. The objective of the work is the refinement of the existing cross-section model. The new version must be tractable numerically and provide design information on the probability of detection for various kinds of targets.

GROUND WAVE RADAR COVERAGE WITH THREE STATIONS



Ground Wave radar technology for shore-based systems developed by Memorial University's Faculty of Engineering and Applied Science and C-CORE is being transferred to Northern Radar Systems Limited. Three GWR sites on the coast of Newfoundland will provide coverage of the busiest offshore areas in Eastern Canada.

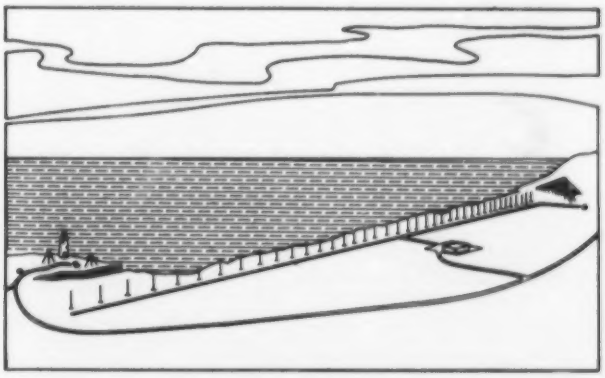
Target Detection

The Northern Radar Systems Limited (NRSL) Project

For nearly a decade, research on Ground Wave radar (GWR) has been conducted at Memorial University's Faculty of Engineering and Applied Science and at C-CORE. Industry and government have been keenly interested in the results of this major research program, and have invested over four million dollars in the research. In 1986 the GWR research reached a stage at which it was natural to transfer the technology to the private sector and so Northern Radar Systems Limited (NRSL) was established to achieve this objective.

A large portion of the C-CORE Remote Sensing Group's time from November 1988 to June 1990 will be committed to the NRSL project. The project's immediate goals are to build a shore-based Ground Wave radar site which will be operational at Cape Race, Newfoundland. C-CORE staff will be working on the technical aspect of the project funded by NRSL.

Over the horizon detection with Ground Wave Radar.



Ground Wave Radar Station Concept

Iceberg Detection — NSERC Co-operative R & D Grant

The Ice Hazard Detection Ground Wave Radar program is developing the Ground Wave radar technology for use on drilling rigs or vessels. The program addresses problems encountered in the offshore environment: ocean clutter, platform motion and the need for compact rig based antenna systems. Extensive signal processing research is being carried out to develop algorithms to deal with these problems.

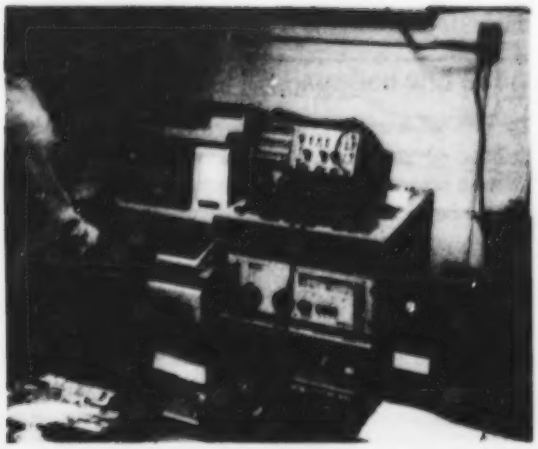
The Centre is in the final year of the NSERC Co-operative R & D grant supporting iceberg detection. Northern Radar Systems Limited, Mobil Oil Canada Properties and Husky Bow Valley East Coast Project are the industrial partners. The field program to collect radar return from iceberg targets took place in June 1989 at a coastal site near Lumsden, in north-eastern Newfoundland. The field base was set up and operated through the iceberg season. Returns from small icebergs and growlers were collected. The program objective was to test new detection techniques and to establish detection threshold (limits) for glacial floating ice targets. The results will be used to develop motion compensated Ground Wave radar systems for drilling rigs.

Environmental Measurements

Remote Sensing of Ocean Wave Conditions

The interpretation of wave spectra for Ground Wave radar technology has been applied to the estimation of the ocean wave spectrum. Basic analytical modelling of the ocean surface return, interpretation of measured data using the models and signal processing and data analysis techniques were undertaken. This program was carried out co-operatively with researchers from the Bedford Institute of Oceanography which provided information on ocean surface modelling and identified user requirements in the oceanographic community. This program developed specifications for a Ground Wave radar system for ocean wave observations to be incorporated into shore based or rig and vessel based radar systems.

The work performed under the NSERC strategic grant to support wave remote sensing is completed. The research finalized new algorithms to extract wave conditions from the measured radar return.



Above: C-CORE researcher operating the CODAR (Coastal Ocean Dynamics Applications Radar) system during the first phase of the surface current measurement study at Barkley Sound. (C-CORE News, Vol. 13, No. 2, p. 7). Right: CODAR transmit antenna at Amphitrite Point Lightstation, Vancouver Island, B.C.

C-CORE and Seaconsult Marine Research Ltd. are now undertaking the second phase of the field experiment on the west coast of Vancouver Island at Pachena Point and Carmanah Lightstations to cover the Swiftsure Bank.

Coastal Ocean Dynamics Applications Radar (CODAR)

Surface Current Measurements

Surface Current Measurement techniques using Ground Wave radars are at a relatively mature state. Systems are available for current survey measurements (short range), and current interpretation algorithms may be utilized with the long range shore based prototype system when it is available. The Centre is presently exploring commercial applications for the techniques, including search and rescue applications, to be carried out in co-operation with the private sector.

C-CORE and Seaconsult Marine Research Ltd., of Vancouver, formed a joint study team to conduct CODAR (Coastal Ocean Dynamics Applications Radar) surface current measurements at Barkley Sound, Vancouver Island during May-June, 1988. The study involved surface current monitoring for one month in the Loudoun and Silver Eagle Channels and on the shelf outside the Sound. The CODAR data was evaluated and compared to measurements from other surface current sensors.

The second field data collection for surface current measurements for the Swiftsure Bank off the west coast of Vancouver Island was conducted during October 1988. The measurement program with the two upgraded CODAR systems went very well with essentially 100 percent data recovery for the experimental period.

The automation of the CODAR system had three objectives. (1) The processed radial current vectors should be able to be sent as the data is collected. (2) The master station should be able to query the status of the operating radar systems. (3) The operator should be able to control the operation of both CODAR sites from the master site or with a remote terminal. There are ongoing discussions with government agencies about using CODAR to provide real time measurement of surface drift during search and rescue. This application of Ground Wave radar has been promoted during our development program.

Associates of C-CORE

1988-1989

GOVERNMENT OF CANADA

Energy, Mines and Resources Canada
Fisheries and Oceans Canada
National Research Council Canada

GOVERNMENT OF NEWFOUNDLAND & LABRADOR

Department of Development

OIL AND GAS INDUSTRY

Bow Valley Industries Ltd.
BP Canada Inc.
Canterra Energy Ltd.
Esso Resources Canada Limited
Gulf Canada Resources Limited
Husky Oil Operations Ltd.
Mobil Oil Canada Properties
Petro-Canada Resources
Shell Canada Limited

CONSULTING INDUSTRY

Advance Geophysical Corporation
Bantrel Group of Engineers Ltd.
Bechtel Canada Limited
Brüel and Kjaer Canada Ltd.
CANPOLAR Consultants Ltd.
CORETEC Inc.
Fenco Newfoundland Limited
GEOTECHnical Resources Limited
Golder Associates
IKU Sintef Group
INSTRUMAR Limited
MacLaren Plansearch Limited
Northern Radar Systems Limited
Newfoundland and Labrador Hydro
NewTel Systems Ltd.
NORDCO Limited
NorTek Engineering Inc.
Royal Bank of Canada
Seaconsult Marine Research Ltd.
TYDAC

Centre For Cold Ocean Resources Engineering

Auditors' Report
Financial Statements

March 31, 1989

KPMG Peat Marwick

Chartered Accountants

Cabot Place
Suite 800
100 New Gower Street
St. John's, Newfoundland A1C 1J3

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AUDITORS' REPORT TO THE BOARD OF GOVERNORS

We have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at March 31, 1989 and the statements of revenue, expenditure and surplus and changes in financial position for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as we considered necessary in the circumstances.

In our opinion, these financial statements present fairly the financial position of the centre as at March 31, 1989 and the results of its operations and the changes in its financial position for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

The comparative figures for 1988 were reported on by another auditor.

Peat Marwick

Chartered Accountants

St. John's, Canada

June 30, 1989

Member Firm of
Klynveld Peat Marwick Goerdeler

Centre for Cold Ocean Resources Engineering

Balance Sheet

March 31, 1989, with comparative figures for 1988

		1989	1988
Assets			
Current assets:			
Research Trust (Note 3)	$	2,719,722	2,047,023
Accounts receivable		540,101	311,379
Total current assets		3,259,823	2,358,402
Fixed assets:			
Bartlett Building, at cost		1,080,211	1,080,211
Equipment, at cost less accumulated depreciation of $1,573,828 (1988 - $1,244,212)		758,973	475,422
Net fixed assets		1,839,184	1,555,633
	$	5,099,007	3,914,035
Liabilities and Equity			
Current liabilities:			
Accounts payable and accrued liabilities	$	66,283	63,427
Deferred revenue		–	76,668
Advance from Memorial University of Newfoundland		503,848	260,215
Total current liabilities		570,131	400,310
Long-term liabilities:			
Interest-free demand loan from Memorial University of Newfoundland (Note 4)		180,598	205,598
Total liabilities		750,729	605,908
Equity:			
Equity in Research Trust		2,719,722	2,047,023
Equity in Bartlett Building		1,080,211	1,080,211
Surplus		548,345	180,893
Total equity		4,348,278	3,308,127
	$	5,099,007	3,914,035

See accompanying notes to financial statements

On behalf of the Board

G Eaton — Chairman of the Board

W. Wayne Thistle — Chairman of Finance and Audit Committee

Centre For Cold Ocean Resources Engineering

Statement of Revenue, Expenditure and Surplus

Year ended March 31, 1989, with comparative figures for 1988

		1989	1988
Revenue:			
Research contracts	$	1,884,093	1,216,726
Research Trust		1,380,271	1,145,553
Other		51,585	22,058
Total revenue		3,315,949	2,384,337
Expenditure:			
Staff salaries		1,739,361	1,379,392
Research programs		847,505	511,301
Support services		234,914	189,744
Ocean Engineering Information Centre		90,032	85,172
Fellowships and training		27,958	23,755
Board of Governors		4,777	6,862
Audit fees		3,950	2,500
Total expenditures		2,948,497	2,198,726
Excess of revenue over expenditures		367,452	185,611
Surplus (deficit), beginning of year		180,893	(4,718)
Surplus, end of year	$	548,345	180,893

See accompanying notes to financial statements

Centre For Cold Ocean Resources Engineering

Statement of Changes in Financial Position

March 31, 1989, with comparative figures for 1988

		1989	1988
Operating activities:			
Net income	$	367,452	185,611
Add items not affecting working capital			
Depreciation		329,616	230,833
		697,068	416,444
Net changes in non-cash working capital balances relating to operations			
Accounts receivable		(228,722)	82,316
Accounts payable and accrued liabilities		2,856	4,433
Deferred revenue		(76,668)	(76,667)
Advance from Memorial University of Newfoundland of Newfoundland		243,633	(78,209)
Cash provided by operating activities		638,167	348,317
Investing activities:			
Purchase of fixed assets		(613,167)	(323,317)
Cash applied to investing activities		(613,167)	(323,317)
Financing activities:			
Net change in Research Trust (Schedule)		672,699	1,090,539
Repayment of demand loan from Memorial University		(25,000)	(25,000)
Cash applied to financing activities		647,699	1,065,539
Increase in cash during the year		672,699	1,090,539
Cash held in Research Trust, beginning of year (Schedule)		2,047,023	956,484
Cash held in Research Trust, end of year (Schedule)	$	2,719,722	2,047,023

See accompanying notes to financial statements

Centre for Cold Ocean Resources Engineering

Notes to Financial Statements

March 31, 1989

1. Organization

The Centre for Cold Ocean Resources Engineering ("C-CORE") is a self-reliant organization of Memorial University of Newfoundland (the "University") which is the owner of C-CORE's building and equipment and beneficiary of its assets and liabilities. C-CORE has the exclusive use of the building, known as the Bartlett Building, at no cost to the centre.

2. Significant Accounting Policies

(a) Basis of accounting:

C-CORE follows the accrual basis of accounting except that contributions to C-CORE's research programs are deposited for credit to the C-CORE Research Trust, on a cash basis.

(b) Depreciation:

Depreciation on equipment is provided on a straight-line basis over a period of 5 years. No depreciation is provided on the building.

(c) Support-in-kind:

Various services have been provided to C-CORE by the University and other agencies, without charge, and have not been included in these financial statements.

3. Research Trust

The Comptroller of the University administers the Research Trust on behalf of the Trustee, the Board of Regents of the University.

4. Interest-free Demand Loan

The interest-free demand loan of $180,598 (1988 - $205,598) represents the cumulative difference to March 31, 1985 between revenues and expenditures that have been advanced by the University to C-CORE. This amount was fixed by an agreement between the University and C-CORE dated February 12, 1987 which is effective from March 31, 1986. The amount to be repaid is determined annually.

Centre for Cold Ocean Resources Engineering

Schedule of Research Trust

Year ended March 31, 1989, with comparative figures for 1988

		1989	1988
Contributions:			
Industry	$	349,762	602,250
Government		1,537,500	1,535,000
		1,887,262	2,137,250
Investment income		165,708	98,842
Balance before drawdowns		2,052,970	2,236,092
Drawdowns		1,380,271	1,145,553
Net increase during the year		672,699	1,090,539
Balance, beginning of year		2,047,023	956,484
Balance, end of year	$	2,719,722	2,047,023

C-CORE

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
MEMORIAL UNIVERSITY OF NEWFOUNDLAND
ST. JOHN'S, NF, A1B 3X5, CANADA
TEL. (709) 737-8354 FAX 709-737-4706

Publications for 1988

88-1 Guigné, J.Y., Williams, P.G. and Chin, V.H. "Analysis of the Deformation in a Partially Cracked Welded T-plate". Marine Technology, Vol. 18, No. 4, 1987.

88-2 Guigné, J.Y., Williams, P.G. and Chin, V.H. "A Concept for the Detection of Fatigue Cracks in Welded Steel Nodes". Marine Technology, Vol. 18, No. 4, 1987.

88-3 Bass, D.W. and Woodworth-Lynas, C.M.T. "Iceberg Crater Marks on the Sea Floor, Labrador Shelf". Marine Geology, 79, 1988, pp. 243-260.

88-4 Chari, T.R., Dawe, C.R. and Barbour, S.A. "Model Studies of Wave-Seabed Interaction". Journal of Offshore Mechanics and Arctic Engineering, Vol.109, Feb. 1987, pp. 67-74.

88-5 Barrie, J.V. "Surficial Geology of Hecate Strait, British Columbia Continental Shelf". Geological Survey of Canada, Open File Report, No. 1682, 1988, 74 p. (Also under Barrie, J.V. and Bornhold, B.D. in Canadian Journal of Earth Sciences, Vol. 26, 1989, pp. 1241-1254.)

88-6 Nadreau, J.P., Nawwar, A.M. and Wang, Y.S. "Triaxial Testing of Freshwater Ice at Low Confining Pressures". Proceedings of Seventh International Conference on Offshore Mechanics and Arctic Engineering (OMAE '88), Houston, TX, Feb. 7-12, 1988, Vol. IV, pp. 117-124.

88-7 Guigné, J.Y. "Design and Experimental Development of an Underwater Acoustic Drill". Proceedings of Acoustic-Geotechnical Correlation Workshop NRCC: The Correlation of Acoustic and Physical Properties of Marine Sediments, Calgary, AB, April 16 & 17, 1984, pp. 104-117.

88-8 Josenhans, H.W., Barrie, J.V. and Kiely , L.A. "Mass Wasting Along the Labrador Shelf Margin: Submersible Observations". Geo-Marine Letters, 1987, pp. 199-205.

88-9 Walsh, J. and Donnelly, R. "A Consolidated Approach to Two-Body Electromagnetic Scattering". Physical Review A, Vol. 36, No. 9, Nov. 1, 1987, pp. 4474-4485.

88-10 Lever, J.H., Attwood, D. and Sen, D. "Factors Affecting the Prediction of Wave-Induced Iceberg Motion". Cold Regions Science and Technology, Vol. 15, No. 2, 1988, pp. 177-190.

88-11 Lever, J.H., Sen, D. and Attwood, D. "The Influence of Shape on Iceberg Wave-Induced Velocity Statistics". Proceedings of the Seventh International Conference on Offshore Mechanics and Arctic Engineering (OMAE '88), Houston, TX, Feb. 7-12, 1988, Vol IV, pp. 125-132.

88-12 Guigné, J.Y., Williams, P.G. and Chin, V.H. "An Introduction to the Application of Dynamic Acoustic Intensity Scanning for Non-Contact Detection of Fatigue Cracks". Monograph, Brüel and Kjaer Press, in press.

88-13 Jordaan, I.J., Maes, M.A. and Nadreau, J.P. "The Crushing and Clearing of Ice in Fast Spherical Indentation Tests". Proceedings of Seventh International Conference on Offshore Mechanics and Arctic Engineering (OMAE '88), Houston, TX, February 7-12, 1988, Vol. IV, pp. 111-116.

88-14 Morin, P. and Dawe, C.R. "Geotechnical Properties of two Marine Soils from Labrador Sea Area". Canadian Geotechnical Journal, Vol. 24, 1987, pp.536-548.

88-15 Clark, J.I. and Landva, J. "Geotechnical Aspects of Seabed Pits in the Grand Banks Area". Canadian Geotechnical Journal, Vol. 25, No. 3, pp. 448-454.

88-16 Clark, J.I. and Guigné, J.Y. "Marine Geotechnical Engineering in Canada". Canadian Geotechnical Journal, Vol. 25, No. 2, 1988, pp.179-198.

88-17 Clark, J.I., McKeown, S. and Crawford, C.B. "Field Measurements of the Behaviour of Inclined Footings on a Natural Slope". Canadian Geotechnical Journal, Vol. 25, No. 4, pp. 662-674.

88-18 Guigné, J.Y., Williams, P.G. and Mak, D. "Acoustical Imaging Using a Dais Technique for Non-Destructive Testing". Presented at 17th International Symposium on Acoustical Imaging - Acoustical Imaging '88, June 1988, Sendai, Japan. In: Acoustical Imaging, Vol. 17, H. Shimizu, N. Chubachi and J. Kushibiki eds., Plenum Press, New York, 1989, pp. 237-246.

88-19 Duthinh, D. and Fuglem, M. "Iceberg-Structure Interaction; Force, Energy and Probability". Proceedings of International Association for Hydraulic Research (IAHR) Ice Symposium 1988, Sapporo, Japan, September, 1988, pp.324-340.

88-20 Hodgson, G.J., Lever, J.H., Woodworth-Lynas, C.M.T. and Lewis, C.F.M. (editors). "The Dynamics of Iceberg Grounding and Scouring (DIGS) Experiment and Repetitive Mapping of the Eastern Canadian Continental Shelf". Environmental Studies Research Funds Report No. 094, Ottawa, 318 p. plus appendices, 1988.

88-21 Duthinh, D. "Large Scale Iceberg Impact Tests: Site Selection, Hydraulic Tests and Other Requirements". Proceedings of Ice-Structure Interaction Workshop, Calgary, 1988, pp. 124-133.

88-22 Poorooshasb, F. and James, R.G. "Centrifuge Modelling of a Freefall Penetrator". In **Disposal of Radioactive Waste in Seabed Sediments**, Vol. 18, T.J. Freeman, Editor, Graham & Trotman, London, 1989, pp. 237-255.

88-24 Morin, P. and Pereira, C.P.G. "Sedimentology, Geotechnical Properties and Stability of the Surficial Sediments on the Continental Slope, Southwestern Flemish Pass". Marine Geotechnology, Vol.7, No. 4, pp. 289-316, 1987/88.

88-25 Pereira, C.P.G., Woodworth-Lynas, C.M.T. and Barrie, J.V. "Iceberg Scour Investigations and Sedimentology of the Southeast Baffin Island Continental Shelf". ARCTIC, Vol. 41, No. 3, Sept. 1988, pp. 221-230.

88-26 McKeown, S., Clark, J.I. and Matheson, D. "Frost Penetration and Thermal Regime in Dry Gravel". Journal of Cold Regions Engineering, Vol. 2, No. 3, 1988, pp. 111-123.

Contract Reports

From 1988 on, there will be a separate list for C-CORE Contract Reports. 'C' in the number will indicate that the report is a contract and is not available from C-CORE.

88-C1 Winsor, W.D., Shirasawa, K., Dawe, B., Hickey, K.J. and Hay, A. "Analysis of Data Collected Using CODAR (HF Ground Wave Radar) from the Strait of Belle Isle". C-CORE Contract Report - Bedford Institute of Oceanography.

88-C2 Emory-Moore, M., Solomon, S. and Dunsmore, D. "Placer Potential of Fox Island River and Port au Port Bay: A Preliminary Assessment". Contract Report for Newfoundland Dept. of Mines, Mineral Development Division, Open File No. NTS12B (295).

88-C3 Lever, J.H., Winsor, W.D. and Mitchell, D.K. "C-CORE's Ice Motion Measurement Programme on the LIMEX Cruise 1987". Contract Report for MacLaren Plansearch Ltd.

88-C4 Nadreau, J.P. "Time Series Analysis of Dynamic Behaviour of the Molikpaq". Contract Report for Gulf Canada Resources Limited.

88-C5 Guy, E.V. and Nadreau, J.P. "Beaufort Sea Well Site Characterization Field Data Report for Oceanographic Measurements at South Nipterk, South Omat, West Paqtak". Contract Report for Esso Resources Canada Ltd., Jan. 1988. (Originally cited as "Oceanographic Measurements for 1987-88, Beaufort Sea Well-Site Characterization").

88-C6 Gold, L.W. "Ship and Offshore Structure Icing Research". Contract Report for Centre for Cold Ocean Resources Engineering (C-CORE) and Institute for Marine Dynamics, April 1988.

88-C7 Warren, A.W., Woodworth-Lynas, C.M.T., Guigné, J.Y. "Assessment of the Practicality of Installing a Bedrock Adit, Rock Trench or Overburden Trench for HVDC Cable Protection Beneath the Strait of Belle Isle". Contract report for Newfoundland and Labrador Hydro, June 1988.

88-C8 Duthinh, D., Newell, J., Steel, A., and Winsor, W. "Feasibility Study of Full Scale Iceberg Impact Tests". Contract report for Public Works Canada, DSS Contract EN280-7-1149/01-SZ.

88-C9 El-Tahan, M. and Simms, A. "The Interaction of the Nekton 8000 FPV with Sea Ice and Bergy Bits - Phase I: Ice Environmental Data". Contract report for Nekton Joint Venture (Bouygues Offshore Canada Limited, Newfoundland Design Associates Limited and Pennecon Limited), August 1988.

88-C10 Winsor, W.D., Mitchell, D., Lever, J.H., and Klein, K. "Engineering Design and Costing for an Automatic Ice Motion Package". Contract report for Physical and Chemical Sciences Branch, Department of Fisheries and Oceans, June 1988.

88-C11 Guy, E.V., Hart, S.J., Riskalla, E., and Duthinh, D. "Ice Indentation Experiments, Resolute Bay, April 1988". C-CORE Interim Contract Report No. 1 to Institute for Marine Dynamics, June 1988.

88-C12 Hart, S.J. "Analysis of Data from 1988 Ice Indentation Tests at Resolute Bay, N.W.T.". C-CORE Interim Contract Report No. 2 to Institute for Marine Dynamics, Sept. 1988.

88-C13 Guy, E.V., and Nadreau, J.P. "Final Report on Oceanographic Measurements for 1987-88 Beaufort Sea Well-Site Characterization". Contract Report for Esso Resources Canada Ltd., July 1988.

88-C14 Walsh, J., and Dawe, B. "Model Development for a Study of Ground Wave Radars as Maritime Surveillance Systems II". Contract Report for Dept. of National Defence, 1988.

Information Publications

88-A & 88-B Abstracts - Canadian Meteorological and Oceanographic Society (CMOS), St. John's, NF, June 1987.

88-A Howell, R., Srivastava, S.K. and Walsh, J. "Analysis Methods for the Estimation of Ocean Surface Parameters from Ground Wave Radar Data".

88-B Srivastava, R., Srivastava, S.K. and Walsh, J. "Contribution of Off-Patch Scatter in the Radar Return from the Ocean Surface".

88-C C-CORE News, Vol. 13, No. 1, March 1988, 8 p.

88-D C-CORE Report of Activities 1986-1987, 27 p. Now available upon request.

88-E C-CORE News, Vol. 13, No. 2, July 1988, 12 p.

88-F to 88-J Abstracts of papers presented at the Joint Annual Meeting of the Geological Association of Canada (GAC), Mineralogical Association of Canada (MAC) and Canadian Society of Petroleum Geologists (CSPG) May 23-25, 1988, St. John's, NF.

88-F Emory-Moore, M., Barrie, J.V. and Solomon, S. "Modelling of Two Heavy Mineral Placer Deposits on the Canadian Continental Shelf". p. A37.

88-G Lewis, C.F.M., Lever, J.H., Woodworth-Lynas, C.M.T., Barrie, J.V., Josenhans, H.W. and Parrott, D.R. "Icebergs and the Seabed, Eastern Canadian Continental Margin". p. A73.

88-H Solomon, S.M., Hyde, R.S. and Hiscott, R.N. "Depositional Environment and Fossil-Fuel Potential of Floodplain Deposits of the Upper Carboniferous Barachois Group, Bay St. George Basin, Western Newfoundland". p. A115.

88-I Woodworth-Lynas, C.M.T. "Ice Scours in the Geological Record: Why They Are Not Seen". p. A137.

88-J Woodworth-Lynas, C.M.T. and Matile, G.L.D. "Large Scale Linear Ridge and Groove Topography from Glacial Lake Agassiz and Hudson Strait: Possible Evidence for Buoyant, Surging Ice Sheets". p. A137.

88-K & 88-L Abstracts - Canadian Meteorological and Oceanographic Society, 22nd CMOS Annual Congress, June 1988 Hamilton, ON.

88-K Eid, B.H., Morton, C.M., Winsor, W.D. and Lever, J.H. "Wave-Ice Interaction Study During LIMEX/LEWEX '87".

88-L Jordaan, I.J. and Winsor, W.D. "Load Combinations and Risk Assessment for Ice Structure Interaction in the Marginal Ice Zone".

88-M Walsh, J. and Dawe, B.J. "Ground Wave Radar: Principle and Application". (Abstract) Antem '88, Symposium on Antenna Technology and Applied Electromagnetics, August 1988, Winnipeg, Canada.

88-N Scott, W.J., Solomon, S., Emory-Moore, M. and Guigné, J.Y. "Marine Placer Exploration: New Research Initiatives" (Abstract) Annual Conference of the Underwater Mining Institute, October 1988, Woods Hole, MA.

88-O Luternauer, J.L., Barrie, J.V., and Conway, K.W. "Surficial Geology and Geohazards on the Continental Shelf off Western Canada". In: Current Research, Part E, Geological Survey of Canada, Paper 88-1E, p. 281, 1988.

88-P C-CORE News, Vol. 13, No. 3, November 1988, 12p.

Publications for 1989

89-1 Khan, R.H., Dawe, B.J. and Walsh, J. "Time-Domain Modelling of Ocean Clutter for Ground Wave Radar". Proceedings of the Canadian Conference on Electrical and Computer Engineering, Vancouver, BC, Nov. 1988, pp.715-718.

89-2 Howell, R.K. and Walsh, J. "Extraction of Ocean Wave Spectra from HF Radar Returns". Proceedings of the Canadian Conference on Electrical and Computer Engineering, Vancouver, BC, Nov. 1988, pp.719-722.

89-3 Khan, R.H., Walsh, J. and Benoit, J.R. "Over-the-Horizon Target Detection from a Floating Platform". Proceedings of the 8th International Conference on Offshore Mechanics and Arctic Engineering (OMAE'89), The Hague, March 1989, Vol. IV, pp. 221-228.

89-4 Guigné, J.Y., Pace, N.G. and Chin, V.H. "Dynamic Extraction of Sediment Attenuation from Sub-bottom Acoustic Data". Journal of Geophysical Research, Vol. 94, No. B5, May 1989, pp. 5745-5755.

89-5 Barrie, J.V., Emory-Moore, M., Luternauer, J.L. and Bornhold, B.D. "Origin of Modern Heavy Mineral Deposits, Northern British Columbia Continental Shelf". Marine Geology, 84, 1988, 43-61.

89-6 Josenhans, H.W. and Woodworth-Lynas, C.M.T. "Enigmatic Linear Furrows and Pits on the Seabed of the Upper Continental Slope of the Northwest Labrador Sea: Are They Sedimentary Furrows or Feeding Traces?" Maritime Sediments, Vol. 24, No. 2, 1988, pp. 149-155.

89-7 Luternauer, J.L., Clague, J.J., Conway, K.W., Barrie, J.V. and Blaise, B. "Late Pleistocene Terrestrial Deposits on the Continental Shelf of Western Canada: Evidence for Rapid Sea-Level Change at the End of the Last Glaciation". Geology, Vol. 17, No. 4, 1989, pp. 357-360.

89-8 Guigné, J.Y., Williams, P.G. and Adams, J.G. "Detection of In-service Fatigue Damage in Offshore Structures Using Dynamic Acoustic Intensity Scanning". Proceedings of the 12th World Conference on Non-Destructive Testing, Amsterdam, The Netherlands, April 1989, pp. 478-483.

89-9 Guigné, J.Y., Chin, V.H. and Solomon, S.M. "Acoustic Attenuation Measurements Using Parametric Arrays". Ultrasonics, Vol. 27, Sept. 1989, pp. 297-301.

89-10 Duthinh, D., Newell, J. and Steel, A. "Feasibility of Full Scale Iceberg Impact Tests". Proceedings of the 8th International Conference on Offshore Mechanics and Arctic Engineering (OMAE '89), The Hague, The Netherlands, March 1989, Vol. IV, pp. 383-392.

89-11 Clark, J.I. "The Role of C-CORE in Canadian Cold Ocean Resources Development". Proceedings of the 15th CPA Frontier Division Workshop, Managing Transition on the Canadian Petroleum Frontiers, Fairmont, BC, May 1988, pp. 132-136.

89-12 Poorooshasb, F., Clark, J.I. and Woodworth-Lynas, C.M.T. "Small Scale Modelling of Iceberg Scouring of the Seabed". Proceedings of the 10th International Conference on Port and Ocean Engineering Under Arctic Conditions (POAC '89), Lulea, Sweden, June 1989, Vol. 1, pp. 133-145.

89-13 Woodworth-Lynas, C.M.T. and Guigné, J.Y. "Iceberg Scours in the Geological Record". Presented at Glacimarine Environments: Processes and Sediments, Geological Society London, March 1989. Proceedings in press.

89-14 Poorooshasb, H.B., Poorooshasb, F. and Clark, J.I. "Yielding of Cohesionless Soils Considering Change of State". Invited Paper, 12th International Conference, International Society for Soil Mechanics and Foundation Engineering, August 1989.

89-15 Duthinh, D. "Model Tests of a Semi-submersible in Sea Ice". Proceedings of the Annual Conference of the Canadian Society for Civil Engineering, St. John's, NF, June 1989, pp. 604-616.

89-16 Duthinh, D. "Parametric Study of Iceberg Impact Loads". Proceedings of the 10th International Conference on Port and Ocean Engineering Under Arctic Conditions (POAC '89), Lulea, Sweden, June 1989, Vol. 1, pp. 492-503.

89-17 Winsor, W.D., Clark, J.I., Eid, B.M. and Morton, C.M. "The Role of Ice Properties in Wave-Ice Interaction During LIMEX 1987". Proceedings of the 12th Canadian Symposium on Remote Sensing, IGARSS '89, Vancouver, BC, July 1989, Vol. 4, pp. 2350-2358.

89-18 Clark, J.I. and Poorooshasb, F. "Protection of Sea Bottom Facilities in an Ice Scoured Environment". Proceedings of the Annual Conference of the Canadian Society for Civil Engineering, St. John's, NF, June 1989, pp. 617-632.

89-19 Solomon, S., Emory-Moore, M. and Davis, L. "High Latitude Marine Placer Exploration and Assessment with an Example from Newfoundland, Canada". OCEANS '89, Seattle, WA, Sept. 1989, Vol. 1, pp. 11-16.

89-20 Guigné, J.Y., Atkinson, I. and Linfield, D. "Development of an Acoustic Sub-Seabed Interrogator". OCEANS '89, Seattle, WA, Sept. 1989, Vol. 4, pp. 1055-1060.

89-21 Duthinh, D. "Design Wave Period for a Fixed Structure on the Grand Banks of Canada". OCEANS '89, Seattle, WA, Sept. 1989, Vol. 5, pp. 1329-1334.

89-22 to 89-25 In: "Proceedings of Workshop on Ice toroperties", St. John's, NF, June 1988, National Research Council of Research Council of Canada, Associate Committee on Geotechnical Research, Technical Memorandum No. 144, NRCC 30358.

89-22 Gold, L.W. "Selection of Mechanical Properties for Design". pp. 93-102.

89-23 Lever, J.H. "Design Issues for Iceberg/Structure Interaction". pp.57-60.

89-24 Nadreau, J-P., Chin, S.N., Guy, E.V. and Steel-Fisher, A. "Methods for Sea Ice Indentation Tests". pp.143-148.

89-25 Nadreau, J-P., Guy, E.V., Christian, D. and Christensen, F. "Thin Section of Indented Ice". pp.149-152.

89-26 Emory-Moore, M., Solomon, S. and Dunsmore, D. "Chromitiferous Placer Accumulations in Fox Island River and East-Central Port au Port Bay, Western Newfoundland: A Preliminary Examination of Their Sedimentological Character". Marine Mining, Vol.8, No.2, 1989, in press.

89-27 Lever, J.M., Colbourne, B. and Mak, L. "Model Study of the Wave-Driven Impact of Bergy Bits With a Semi-submersible Platform". Proceedings of the 8th International Conference on Offshore Mechanics and Arctic Engineering (OMAE '89), The Hague, The Netherlands, March 1989, Vol. IV, pp. 393-403.

89-28 Clark, J.I., Chari, T.R., Landva, J. and Woodworth-Lynas, C.M.T. "Pipeline Route Selection in an Iceberg Scoured Seabed". Marine Geotechnology, Vol. 8, 1989, pp. 51-67.

89-29 Emory-Moore, M. and Solomon, S.M. "Placer Gold Potential Offshore Newfoundland: A Preliminary Assessment". Current Research, 1989, Newfoundland Department of Mines, Geological Survey of Newfoundland, Report 89-1, pp. 229-236.

89-30 Scott, W.J., Sellmann, P.V. and Hunter, J.A. "Geophysics in the Study of Permafrost". Society of Exploration Geophysicists, Monograph in Engineering Geophysics, in press.

89-31 Dawe, B.J., Khan, R.H., Walsh, J. and Benoit, J.R. "A Long Range Ground Wave Radar System Off-shore Surveillance". Proceedings of the 12th Canadian Symposium on Remote Sensing, IGARSS '89, Vancouver, BC, July 1989, Vol. 5, pp. 2950-2952.

89-32 Howell, R. and Walsh, J. "Measurement of Ocean Wave Spectra Using Narrow Beam HF Radar". Proceedings of the 12th Canadian Symposium on Remote Sensing, IGARSS '89, Vancouver, BC, July 1989, Vol. 5, pp. 2969-2972.

89-33 El-Tahan, M. "Validation of an Operational Sea Ice Edge Drift Prediction Model". Proceedings of the North American Sea Ice Workshop, Amherst, NS, June 1989, Vol. 1.

89-34 Guigné, J.Y., Atkinson, I. and Smith, F. "Robotics for High Precision Ocean Acoustic Imaging". Proceedings of the Workshop on Military Robotics Applications, Royal Military College of Canada, Kingston, ON, August 1989, in press.

89-35 Khan, R.H. and Mitchell, D.K. "Waveform Design for a High Frequency Ocean Surveillance Radar". Proceedings of the Canadian Conference on Electrical and Computer Engineering, Montreal, PQ, Sept. 1989, pp. 605-608.

89-36 Crocker, G.B. "The Influence of Snowcover on the Growth of Antarctic Fast Ice". Proceedings of 46th Eastern Snow Conference, Quebec City, June 1989, in press.

89-37 Guigné, J.Y. and Chin, V.H. "Optimization of Terminated Parametric Arrays for Underwater Use". Canadian Acoustical Association Proceedings, in press.

89-38 Guigné, J.Y. and Chin, V.H. "Acoustic Imaging of an Inhomogeneous Sediment Matrix". Marine Geophysical Research, in press.

89-39 Josenhans, H.W. and Barrie, J.V. "Submersible Observations on the Labrador Shelf, Hudson Strait and Baffin Shelf". **Submersible Observations off the East Coast of Canada**, D.J.W. Piper, editor, Geological Survey of Canada Paper 88-20, 1989, pp. 41-56.

89-40 Moslow, T.F., Barrie, J.V. and Luternauer, J.L. "Sedimentary Facies of a High-energy, Tide-dominated Continental Shelf, Western Canada". 2nd International Research Symposium on Clastic Tidal Deposits, G.E. Reinson, editor, Calgary, AB, August 1989, pp. 25-36.

89-41 Lever, J.H., Bass, D.W., Lewis, C.F.M., Klein, K. and Diemand, D. "Iceberg/Seabed Interaction Events Observed During the DIGS Experiment". Proceedings of the 8th International Conference on Offshore Mechanical and Arctic Engineering (OMAE '89), The Hague, March 1989, Vol. IV, pp. 205-220.

89-42 Barrie, J.V. "Sediment Transport of the Shelf Margin of the Grand Banks of Newfoundland". Atlantic Geology, Vol. 25, No. 3, in press.

89-43 Scott, W.J. and Maxwell, F.K. "Marine Resistivity Survey for Granular Materials, Beaufort Sea". Canadian Journal of Exploration Geophysics, December 1989, Vol. 24, No. 4, in press.

89-44 Crocker, G.B. and Wadhams, P. "Breakup of Antarctic Fast Ice". Cold Regions Science and Technology, in press.

89-45 Eid, B.M., Morton, C.M., Winsor, W.D. and Cardone, V.J. "Wave-Ice Interaction Study During LIMEX '87. Proceedings of 2nd International Workshop on Wave Hindcasting and Forecasting, April 1989, Vancouver, B.C. Proceedings in preparation.

89-46 Dawe, B.J., Khan, R.H. and Walsh, J. "A Long Range Ground Wave Radar System for Offshore Surveillance". Presented at CRL Radar Symposium, A Canadian Industrial Perspective, McMaster University, Hamilton, ON, October 1989, proceedings in preparation.

89-47 Lien, J., Todd, S., Guigné, J. "Inferences about perception in large Cetaceans, especially hump-backed whales, from incidental catches in fixed fishing gear, enhancement of nets by alarm devices and the acoustics of fishing gear". **Sensory Abilities of Cetaceans**, J. Thomas, ed. Plenum Press, New York, in press.

89-48 Fuglem, M.K., Duthinh, D., Lever, J. and Jordaan, I. "Probabilistic Determination of Iceberg Collision Design Loads for Floating Production Vessels". IUTAM/IAHR (International Union of Theoretical and Applied Mechanics / International Association for Hydraulic Research), Proceedings of Symposium on Ice/Structure Interaction, St. John's, NF, Aug. 1989, in press.

Contract Reports

'C' in the number indicates that the report is a contract and is not available from C-CORE unless specified otherwise.

89-C1 Woodworth-Lynas, C.M.T. and Landva, J. "Sediment Deformation by Ice Scour". Contract Report for Dept. of Supply and Services (No. 2 3420-7-M536/01-OSC).

89-C2 Guigné, J.V. and Solomon, S. "Sub-bottom Profiling with Ultrasound for Environmental Monitoring: Review of Current and Experimental Work Using Fixed-Transducer Monitoring and Acoustical Mapping". Contract Report for Environment Canada No. KW405-8-2061. This report will be made available as a C-CORE Technical Report.

89-C3 Woodworth-Lynas, C.W.L. "Iceberg Grounding Event at the Whiterose Wellsite, April 9-12th, 1988". Contract Report for Husky Oil East Coast Project.

89-C4 Guigné, J.Y. and Williams, P.G. "Dynamic Acoustic Intensity Scanning for the Detection of Fatigue in Offshore Structures". Contract Report for Department of Energy, Mines and Resources, DSS Contract Number 23440-6-9208/01-SQ.

89-C5 C-CORE. "The Interaction of the Nekton 8000 FPV with Sea Ice and Bergy Bits, Phase II: Wave Driven Bergy Bit Tests". Contract Report for The Nekton Joint Venture (Bouygues Offshore Canada Limited, Newfoundland Design Associates Limited and Pennecon Limited), Jan. 1989.

89-C6 Duthinh, D. "The Interaction of the Nekton 8000 FPV with Sea Ice and Bergy Bits, Phase III: Sea Ice Tests". Contract Report for The Nekton Joint Venture (Bouygues Offshore Canada Limited, Newfoundland Design Associates Limited and Pennecon Limited), Jan. 1989.

89-C7 Fuglem, M. and Jordaan, I. "The Interaction of the Nekton 8000 FPV with Sea Ice and Bergy Bits, Phase IV: Risk Analysis". Contract Report for the Nekton Joint Venture (Bouygues Offshore Canada Limited, Newfoundland Design Associates Limited and Pennecon Limited), Jan. 1989.

89-C8 Solomon, S., Guzzwell, J. and Guigné, J. "Crude Storage Gelling and Waxing Study". Contract Report for Mobil Oil Canada Properties.

89-C9 El-Tahan, M. "Iceberg Statistics for the Grand Banks Area". Contract Report prepared for Compusult Ltd. and BP Resources Canada Limited.

89-C10 Simms, A. "Iceberg Scour Statistics for the Flemish Pass and Jean d'Arc Basin Region". Contract Report prepared for Compusult Ltd. and BP Resources Canada Ltd., April 1989.

89-C11 Guigné, J.Y., Solomon, S.M. and Hunt, P. "Correlation of Acoustic and Core-Derived Stratigraphy in Hamilton Harbour, Lake Ontario". Contract Report for Department of the Environment, Ottawa, ON, Contract No. KW405-8-2061.

89-C12 Guigné, J.Y., Williams, P.G. and Adams, J.G. "Directional Response of a Dedicated Three Dimensional Intensity Hydrophone Array". Contract Report for NORDCO Ltd.

89-C13 Crocker, G.B. "Environmental Monitoring and Ice Growth Modelling in Roti Bay, Newfoundland". Contract Report for Seabright Corporation Ltd., July 1989.

89-C14 Guigné, J.Y. and Williams, P.G. "Dynamic Acoustic Intensity Scanning of Propagating Fatigue Cracks in Compact Type Specimens". Contract Report for Department of Energy, Mines and Resources, DSS Contract Number 23440-6-9208/01-SQ.

89-C15 Poorooshasb, F. "Large Scale Laboratory Tests of Seabed Scour". Contract Report for Fleet Technology Ltd., November 1989.

Information Publications

89-A C-CORE News, Vol. 14, No. 1, March 1989, 12 p.

89-B Emory-Moore, M. "Marine Placer Resources on the Canadian Shelf; Will They Pan Out?". Newsletter of Marine Geosciences Division, Geological Association of Canada. C. Woodworth-Lynas and W. Collins (eds.), Vol 2, No. 1, 1989, pp. 17-20.

89-C Scott, W.J., Solomon, S. and Emory-Moore, M. "The Marine Mining Program at C-CORE". Oral presentation at Annual Meeting of GAC Newfoundland, St. John's, NF, March 2, 1989.

89-D Scott, W.J. "Development of Marine Resistivity and Induced Polarization Systems". Presented at AGM of Canadian Geophysical Union, Montreal, P.Q., May 1989.

89-E C-CORE Report of Activities 1987-1988, 26 p. Now available upon request.

89-F C-CORE News, Vol. 14, No. 2, July 1989, 15 p.

89-G Crocker, G.B. and Werle, D. "Some Observations of the Snowcover on Sea Ice in the Gulf of Bothnia" (Abstract). Proceedings of IGARSS '89 - 12th Canadian Symposium on Remote Sensing, Vancouver, BC, July 1989, p. 2364.

89-H and 89-1 Abstracts of papers presented at the Technical Cooperation Program (TTCP) (Subgroup K) HF Surface Wave Radar Symposium, Naval Research Laboratory, Washington, DC, March 1989.

89-H Khan, R.H. "Northern Radar Systems Limited Prototype Ground Wave Radar".

89-I Walsh, J. "Ground Wave Radar Research at MUN/C-CORE".

89-J Guigné, J.Y., Pike, C.J. and Inkpen, T.S. "1500 Hz 3-D Acoustic Imaging of the Near Sub-seabed". (Abstract) Presented at the joint Canadian Society of Exploration Geophysicists and Canadian Society of Petroleum Geologists national convention in Calgary, June 11, 1989.

89-K C-CORE News, Vol. 14, No. 3, November 1989, 15 p.

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